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ANNUAL REVIEW OF LITERATURE ON RADIOACTIVITY STUDIES OF AIR, WATER, AND WASTES (1954)

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February 1955

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ANNUAL REVIEW OF LITERATURE ON RADIOACTIVITY STUDIES OF AIR, WATER AND WASTES

Edited By

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Prepared in part for the Research Committee
of the
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RADIOACTIVITY

General

Revisions were made in the recommendations of the International Commission on Radiological Units at the Seventh International Congress of Radiology, Copenhagen, Denmark, in July, 1953 (49). The major change was the establishment of the "rad" as a unit of absorbed dose imparted to matter by ionizing radiation at the place of interest. One rad is equal to 100 ergs absorbed per gram of material.

Concerning tolerance levels, Morgan and Ford (50) derived maximum permissible levels of radioisotopes for single exposure and for body excretion with either chronic or single exposure. Exposure to the gastro-intestinal tract was frequently found to be critical. As a result some MPC values were lowered by large factors. The results obtained from examining human bone marrow (46) suggest that the tolerance dose for inhaled radon-222 (plus daughters) should be 10 to 100 times lower than the present value, which is based on roentgen and gamma ray exposure.

On the other hand, new studies on the toxicity of plutonium-239 (6) indicated that the maximum permissible concentration in drinking water could be raised, according to M. H. Weeks of General Electric. If this were done, savings in both time and money could be made in treating the effluents of the Hanford plutonium works.

Natural Background

Background values of natural airborne alpha activity were determined over a period of nine months by Mercer (74). Average values for RaA and ThB deposited on membrane filters were found to be 0.13 and 0.0052 micro-microcuries per liter (μμc/l), respectively.

Hursh (48) determined the radium content of raw and finished water samples of 41 cities in the United States. Eight of the cities were supplied with well water having a radium content varying from 0.027 (Phoenix, Arizona) to 6.55 (Joliet, Ill.) micro-micrograms per liter (μμg/l) of raw water. Except for the Allegheny, Missouri, and Mississippi rivers, which had 3.7, 1.77, 1.08, and 0.425 μμg/l of raw water at Pittsburgh, Omaha, St. Louis, and New Orleans, respectively, the radium content of surface water was less than 0.2 μμg/l. Except for the Joliet, Illinois supply, the radium content of tap water was found to be less than 0.2 and usually less than 0.1 μμg/l.

Flores (30) reported the natural radioactivity of 17 Central American spring and well waters varied from 11 to 1875 μμc/l. The minimum values were found in the waters near San José, Purúa and the maximum value was found in the El Penon water near Mexico City.

Trembaczowski (106) found the radioactivity of Slavinek Springs near Lublin, Poland was 1.12-1.43 Mache units. These values are of the same magnitudes as those of other resort springs.

The natural background alpha radioactivity of rain, surface and hot spring waters has been determined by a number of investigators, some of whose results are tabulated below:

Location and Kind of Sample	Radioactivity Measured Kind	μμc/l	Ref.
Arkansas, streams	Rn	8.4-1070	(8)
Arkansas, lakes	Rn	< 1-123	(8)
Arkansas, well	Rn	58,750	(8)
U. S. and Japanese, rain	Rn	< 10	(63)
U. S. hot springs	Rn	100-3000	(62)
U. S. cold springs	Rn	100-7300	(62)
Japan, Masutomi, spring	RaC'	> 1,000,000	(63)
Japan, Masutomi, rain	RaC'	15,000-34,000	(63)
Japan, Tokyo, rain	RaC'	5000-25,000	(63)
Spain, natural waters	Rn	370-174,000	(96)

Libby (68) reported results of assays for the natural tritium content of rain, surface waters and wines of different vintages from various locations.

The amount of radioactivity in air was measured from April to September at altitudes from 1460 to 3500 meters by Garrigue (33). The tabulated results showed well-defined invasions of activity on August 15, August 28 and September 5, 1953.

Terrill, Ingraham and Moeller (105) reviewed the natural occurrence of radioactivity in water, minerals, and organic materials in the U. S. as related to toxicity for man. Both medical and industrial uses are discussed for radium and its decay products. Techniques in use are reviewed as a potential or real health hazard. More than 200 per cent of the maximum tolerable concentration has been detected in industries using luminous paint processes and mining operations.

Fall-out

Measurements conducted by Santomauro (94) between February, 1951 and November, 1952 showed that nuclear weapon tests at Las Vegas, Eniwetok and Montabello were followed one, two and three weeks later, respectively, by an increase in the radioactive content of rain and snow falling in Italy. From March 19, 1953 until the middle of June, the atmospheric radioactivity was measured by Haxel and Schumann (45) at Heidelberg, 565 meters above sea level. Diagrams show the amount of radioactivity found. The amount of radioactivity over the Parisian area increased with the Nevada tests of March to June, 1953 and with the Russian tests in September, according to Abribat and Pouradier (1).

Kilcawley, et al (59) reported a study made on the radioactivity of rain and the water in several reservoirs in the Troy, New York area from May 15 to August 31, 1953 following the detection of considerable rain-out during a storm on April 26. The reservoir waters usually contained a beta activity of 10 to 100 μμc/l as compared to a beta activity of 200 to 30,000 μμc/liter in the rain.

Nader, Goldin and Setter (82) determined the beta radioactivity of precipitation in the Cincinnati, Ohio area for 12 months beginning in March 1953. The background level of 30 to 80 μμc/l prior to March 18 increased to a maximum of 31°,000 μμc/l on April 29. The rain-out was identified by decay data as mixed fission products usually corresponding to the age of specific bomb bursts. It was estimated that a total of 13.5 curies of activity fell per square mile between March 18 and July 25. The accumulated rain-out would have decayed to 0.15 curies/square mile by December 1, 1953.

From a study of the radioactivity of surface and treated waters of the Cambridge and Lawrence, Massachusetts and Rochester, New York water supplies in April-June, 1953, Bell, Thomas and Rosenthal (13) concluded that only approximately 55 per cent of the 2 to 30 day-old bomb debris found in surface water was removed in passage through rapid sand filtration plants. A lesser percentage (4-40 per cent) of residual debris of greater age was removed.

Garrigue (34) measured the radioactivity on Puy-de-Dome, France and in the air above it from October 10, 1953 to November 3, 1953. It was concluded that all radioactivity found was from cosmic radiation.

Van Middlesworth (110) tested the I^{131} in thyroid samples of cattle and sheep from Tennessee, Massachusetts, and Oklahoma collected in June and July, 1953. The activity found varied from 4800 μμc/g of tissue in June 12-14, to 60 μμc/g in July.

Fall-out estimates of the predominant chemical species resulting from a shallow underwater burst of an atomic bomb were given by Bunney and Ballou (18). It was predicted that the halides, alkali metals, and alkaline earth metals should appear as ionic species in their normal valence states. Several other elements, e.g., P, S. Ge, As, Mo, Tc, and Te, should occur as oxygenated anions and nearly all of the remaining elements, e.g., Ce, Nb, Ru, Y and Zr (41), should exist as oxides or hydrated oxides associated with colloidal or gross particulate matter.

Contamination and Decontamination

Coleman and Silverman (22) studied radioactive particulate matter and gases from reactors. Suitable ventilation controls for these radioactive materials include removal of particulate matter from incoming air, the use of reduced pressures to prevent leaks, induced air flow toward "hottest" areas, and dilution. Decontamination processes use filters, settling chambers, electrostatic precipitators, wet collectors and high stacks for dilution. Leary, Clark and Hammond (65) presented performance data on a wet cell glass-wool filter designed for the removal of radioactive particulates from air.

The maximum possible hazard from a nuclear incident, in which all of a reactor's radioactive contaminants are dispersed into the air, was evaluated by Mesler and Widdoes (75). This evaluation considers external, inhalation and fall-out doses and suggests steps which can be taken to reduce these hazards. The successful restoration program following an accident at Chalk River was described by Gilbert (36). The reactor had released several thousand curies of fission products into the building and onto equipment.

A similar problem of decontaminating a high level chemistry cell was described by Conlan and Smith (23). Comparative decontamination tests on stainless steel contaminated with Hanford U dissolver solution were reported by Kattner (53). Sandblasting was considerably more thorough than the usual chemical method. Sandblasting not only reduced the decontamination time, but also removed over 99 per cent of the contamination.

The extent of surface contamination by uranium and radium in connection with ore refining was evaluated by using G-M survey meter readings with and without the gamma shield (9).

Surveys and Water Treatment

The comprehensive monitoring service at the Hanford Works (5) indicated that the problems of disposing of air-borne and solid radioactive isotopes, as well as those in water solution or suspension, were carefully worked out and that no hazards to human health have occurred. From a study of the radioactivity of the Columbia River below the Hanford reactors, Foster and Rostenbach (31) concluded that since the levels of activity are well below one-tenth of the maximum permissible concentration, "no health hazards to users currently exists". Even if game fish were caught in the most radioactive section of the river, a person could eat 20 lbs. daily without exceeding permissible radioactivity limits". Tests were reported by Brockett and Placak (14) on the retention of radioactive wastes in shale by percolation through small columns and by shaking with clay suspensions. Under laboratory conditions 98 to 100 per cent of Ba^{140}, Ce^{144}, Cs^{137}, P^{32}, Ru^{106}, Zr^{95} was removed. Only 80 per cent of the Sr^{90} was removed. An increase in dosage of shale from 1000 to 40,000 p.p.m. affects removal very little except with Sr^{90} and P^{32}. Base exchange ratings do not necessarily indicate the removal effectiveness. Chemical form of the isotope affects removal.

Clinch River (Tennessee) water with added radioactivity and with or without various clay and silt additions was used by Goodal, Gloyna and Carritt (19) (40) in a study of coagulation with ferrous sulfate, lime and phosphate for the removal of strontium and mixed fission products. Depending on the kind of contaminant and on the kind and amount of chemical agents and the pH of coagulation, the removal achieved varied from 60 to over 95 per cent.

The fate of radioactive strontium during the treatment of water by conventional process was investigated by Downing, Wheatland and Eden (27) and reviewed by Southgate (98). Only a small portion of the activity was removed during chemical coagulation as normally carried out. A higher proportion was removed when a very large dose of coagulant was added, and during softening by chemical methods. Softening by ion exchange removed over 97 per cent of the activity.

In studying the capacity of the lime-soda water softening process for the removal of radiostrontium from water, McCauley, Lauderdale and Eliassen (73) found that coprecipitation with calcium as a mixed carbonate crystal gave maximum removal. By use of the process it was possible to reduce the strontium activity from 200 counts per second or higher to near background. Eden, Elkins and Truesdale (27) investigated the removal of the radioactive nuclides, Sr^{90}, Ru^{106}, I^{131}, Cs^{134}, Ce^{144}, and Pu^{239}, from water by slow sand filtration and by activated sludge sewage treatment. The removal by slow sand filtration was relatively high at first until equilibrium was reached in 0.5 to 5 or more days depending on the isotope. At equilibrium very little of the Sr^{90} and Ru^{106},

about 50 per cent of the I^{131}, 90 per cent of the plutonium and over 99 per cent of the Ce^{144} was removed. The activated sludge studies consisted of adding an isotope to activated sludge (5000 ppm suspended solids) grown on nutrient solution. The mixture was aerated for 200 hours. Samples were collected periodically, centrifuged and the clear liquor tested. The uptake of activity generally increased with time and depended upon the pH of the sludge mixture. The uptake after two hours aeration was greatest at pH 7 to 10 for Sr^{90} and mixed fission products three years old, high for cerium over a pH range of 2 to 10, high for plutonium (over 90 per cent removal at pH less than 7, but only 40 per cent at pH 10), low for cesium-134 (but greatest at pH 9-10) and least for ruthenium-106 (less than 15 per cent over the entire pH range).

Additional studies at the Oak Ridge National Laboratory by Straub and Krieger (101) and Lacy (64) show clay suspensions (2500 to 5000 ppm) are capable of removing about 90 per cent of the added Co^{60}, Zn^{65}, Se^{75}, Ta^{182}, Ir^{192}, Tl^{204}, in a 30-minute contact time and that a dose of 1000 ppm clay is quite effective for removing Ce^{141}, $Ce^{144}(Pr^{144})$, $Zr^{95}(Nb^{95})$, $Ba^{140}(La^{140})$ and $Sr^{90}(Y^{90})$. Clay was less effective for $Ru^{106}(Rh^{106})$ and very poor for I^{131}. The removal was not affected by calcium concentration, but improved when the pH was greater than 5.

Sewage and Industrial Waste Treatment and Disposal

Studies were made by Klein, Greenberg and Kaufman (56) (57) on the removal of mixed fission products and radioactive strontium from both domestic sewage and synthetic sewage substrate. The activated sludge and trickling filter processes were found to remove from 70 to 85 per cent of the fission products one to three years old. Versene in sewage caused the elution of fission products from trickling filter slimes. Generally, the removal of strontium did not exceed 20 per cent and was dependent on the mineral composition of the sewage substrate.

Steel and Gloyna (100) operated sewage oxidation ponds with associated algal growths for the removal of radioactivity. The most effective way of separating radioactive-contaminated organisms and associated debris from oxidation pond effluent was found to be by filtration of the suspension through a diatomaceous earth cake. The cost of diatomaceous earth was about 15 cents/1000 gallons of algae-water treated. The filtered effluent was clear, free of color and suspended matter. Chemical precipitation and settling with subsequent filtration of the chemical sludge was expensive and removal was not as effective as vacuum filtration through a diatomaceous earth precoat.

Clark (21) described the waste disposal and decontamination laundry facilities at the Livermore Research Laboratory. Photographs of the facilities and some of the procedures are included. Studies on the removal of radioactivity from laundry wastes by the activated sludge process and by slime organisms, were reported by Reading, et al (90) and Gloyna (38) (39), respectively.

The design and process efficiency of a kilocurie waste gas and liquid processing and disposal plant was described by Leary, Clark and Hammond (66). Provisions were made for storage and handling of high-level gamma-emitting liquids, dusts, and fumes, typical of wastes from a radiochemical processing laboratory. Separate waste streams for alpha-emitters are employed. Design capacity of the system is 2 gpm of liquid and 30,000 cfm of air.

A decontamination factor of 500 was obtained by Lowe, et al (71) by chemically precipitating radioactive process wastes with a one cycle ferrous sulfide, $Fe(OH)_2$, and $Ca_3(PO_4)_2$ treatment. A decontamination factor of 100,000 was obtained for a 3 cycle treatment process. High volume reductions were realized by filtration, whereas the volume reduction expected by settling alone was 10 to 1.

The methods for the treatment of various process wastes to remove radioactivity was reviewed by Rodger (92). Storage of high level solid wastes was considered inevitable. Rodger, et al (93), gave a detailed description of the disposal operations at the Argonne National Laboratory which includes evaporation, incineration, air cleaning and concrete sealing.

The disposal of liquid wastes from the Brookhaven National Laboratory (15), their control programs concerning waste disposal (35) and research studies underway on the ultimate disposal of radioactive wastes (37) were reported. The research studies involve the adsorption of radioactivity in liquid waste by various clays which are subsequently heat treated to fix the radioactivity in fused particles for storage (land or sea) or for use in industry.

Results are presented on the decontamination of waste waters high in dissolved salts and at various acidities after passage through clay columns and on the elution of radioactivity from clay after heat fixation at temperatures varying from 110 to 905°C.

Evaporation as a method of concentration for storage or disposal of Hanford fission wastes and process wastes high in sodium nitrate was discussed by Hirsh (47) and by [illegible] Manowitz and Hatch (72). The wastes disposal practices, problems and costs of over 1000 users of radioisotopes was summarized by Miller, et al (76). Construction material suitable for the handling and storage of corrosive radioactive wastes was reviewed by Griffiths (42). Safe methods for the packaging of radioactive wastes for sea disposal were recommended and various facets of this type of disposal were discussed by the Subcommittee on Waste Disposal and Decontamination of the National Radiation Protection Committee (102). Additional information appeared on regulations for interstate shipment (4) and on sea disposal (29).

Utilization

A symposium (111) on the utilization of fission products was held at Hartwell on February 23 and 24, 1953. The symposium included papers on: the specific activity of separated fission products from reactor fuels; the technical feasibility of the use of fission products, the separation of long-lived fission products, the preservation of food and pharmaceuticals and a comprehensive bibliography on fission product utilization. Young (116) prepared a bibliography consisting of 92 references on the utilization of

gross fission products. Other references on fission product utilization include Brownell (16) on destruction of bacteria, molds, yeasts and viruses; Brownell, et al (17) on the sterilization of foods and pharmaceuticals with a ten-kilocurie gamma source; the Argonne Laboratory (7) experimentation on fission products contained in concrete crocks for food sterilization; and Aiken(2) on disposal and uses of fission products.

Watkins, Wade and Mardock (112) reported the successful use of radioactive iodine as a tracer in water-flooding operations of the petroleum industry. Truesdale (107) found radioactive rubidium to be a good tracer in determining patterns of sewage flow in sedimentation tanks and trickling filters.

Biological Effects

Nishita, et al (84) investigated the adsorption of water-soluble, exchangeable and non-exchangeable forms of long- and medium-lived fission products (Sr^{89}, Sr^{90}, Y^{91}, Ru^{106}, Cs^{137}, and Ce^{144}) on eight soils and two clay minerals. The kind of clay mineral and the kind of adsorbed ion influenced fixation of isotopes. The extractability of Y^{91} and of Ce^{144} followed their respective hydrolysis curves. Plant uptake from the contaminated soils was then investigated. A relatively large amount of Sr^{90} was adsorbed and translocated to plant tops. The uptake of Y^{91}, Ru^{106}, and Ce^{144} was very small, and in most cases their translocation to plant tops was insignificant.

Rediske and Selders (91) investigated the uptake of yttrium by various higher plants. Tomato exhibited the greatest uptake efficiency (leaf to root ratio of 2×10^{-3}). Little loss occurred from the massive radioactive accumulation on the roots even when the plants were changed to solutions free of yttrium.

Porter and Knauss (60) (86) used radioactive tracers to determine the quantities of an element present in Chlorella when the nutrient concentration of that element was varied. Elements used in these studies were P, Ca, S, Fe, Mn, Zn, Cu, Br, Y, and H.

Studies were reported (89) of the metabolism and tissue distribution in rats of Ce, Tm, and Ra, in which Ce^{144}, Tm^{170}, and Ra^{223} were used in tracer concentrations. Similar studies by Jowsey, et al (51) were made on the deposition of strontium-90 in rabbit bones following intravenous injection.

Radiochemical Methods

Wizgan (78) presented a rapid method for the determination of strontium activity in the presence of the relatively long-lived fission product activities. The extraneous activities, with the exception of cesium, are removed by an yttrium hydroxide scavenging. The strontium is separated from the cesium in the supernatent solution by a strontium oxalate precipitation. The oxalate precipitate is then transferred to an aluminum disc to be dried and counted for strontium activity. The results agree with those obtained by the fuming nitric acid procedure.

Morgan (79) reported preliminary investigations on the use of versene for selectively chelating calcium. Since the order of chelation of the alkaline earths is Ca>Mg>Sr it would provide a means of separating radioactive strontium from the calcium in urine. With an excess of magnesium present the pH of the specimen is adjusted to 6.0 to 6.5 and allowed to flow through a column of cation-exchanger. Essentially all of the strontium and some of the magnesium is retained by the resin, but practically all of the calcium will pass through. Keenan and Suttle (54) used thenolytrifluoroacetone as a chelating agent for praseodymium. Progress was reported (85) in studies on the radiochemical determination of tracer amounts of Sr^{89} in bulky water samples, in bone, and in urine. Turk (108) developed a modified procedure for the radiochemical analysis of strontium. The results and radiochemical purity obtained for strontium samples prepared by the modified procedure were comparable to samples prepared by the conventional fuming HNO_3 procedure. The modified procedure consists of adding strontium carrier to the sample, removing three $Fe(OH)_3$ scavenging precipitates, and isolating the strontium as $SrCO_3$.

Freiling and Bunney (32) investigated an ion exchange method for the virtually complete separation of Y, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd and Tb from one another in 49 hours using lactic acid eluants of various strength at a pH of 3 and a temperature of 87° C. Keller, Steinberg and Glendenin (55) described a radiochemical investigation of the fission yields of 15 products in the fission of U^{238}. The fission yield vs. mass curve of U^{238} was compared with those of other fissile nuclei.

Hahn and Backer (43) investigated methods for the separation and radiometric determination of Cs^{134} in fission products. Cesium was precipitated with dipicrylamine and with periodic acid, using Cs or K as carrier. Turk (109) separated radioiodine from other mixed fission product except ruthenium by volatilization. Ruthenium was removed from the iodine by serial extraction with CCl_4. The precision of the method for I_2 based on ten samples is $\pm$ 2.6 per cent.

Kleinberg, et al (58) assembled many of the radiochemical procedures in current use for the separation of mixed fission products and heavy nucleides. The document is not readily obtainable, but a comprehensive synopsis of it appears in Chemical Abstracts. Lindenbaum, et al (70) reported on the analysis of mixtures of radioisotopes as phosphates by ion-exchange chromatography and Whitson and Kwasnoski (114) used an electrodeposition method for the determination of uranium alpha activity in urine. Krumholz and Emmons (61)and Cember, Watson and Grucci (20) described wet digestion techniques which have proved satisfactory for the routine preparation of fish and animal tissues for the determination of gross beta radioactivity.

Instrumentation

Seliger and Schwebel (95) of the National Bureau of Standards used 4-pi internal gas flow counters with or without anti-coincidence counting for the primary standardization and 2-pi ionization chambers with formamide counting for the secondary

standardization of beta-emitting nucleides. Various facets of standardization are discussed in detail and a comparison of results on the same samples by many laboratories was made.

Mize and Zaffarano (77) designed and tested the spectrometer for the study of soft beta rays. Beta-ray sources were deposited on thin plastic films and mounted inside the counting chamber in a detection geometry of essentially 4-pi steradians for measuring the absolute intensities of radioactive sources. Nader, Hagee, Setter and Goldin (83) (97) evaluated the performance of an internal proportional counter and, because of its good geometry and sensitivity to low-level, low-energy radiation, selected it for assaying the alpha and the beta activity of water and industrial wastes. Prohaska (87) (88) found the windowless flow and the end-window counters of the Savannah River Project to have excellent operating characteristics and good reproducibility of results. Wheler, Reynolds and Brookbank (113) recommend the use of standard stock solutions of thallium-204 as a reference standard to be used in determining the over-all efficiency of the radioactivity assay of water samples by various techniques of sample preparation and counting.

Fuller (81) made a systematic study of the back-scattering of 2.0-Mev betas from Y^{90} by samples of infinite thickness for 32 elements (Z=4 to 83) and 22 compounds. It was established that the relative back-scattering is a discontinuous function of Z, but strictly linear in Z within each period of the periodic system. The linear equations, relating back-scattering to Z within each period, when solved simultaneously, indicate discontinuities at Z=10, 18, 36 and 54, corresponding to the rare gases which terminate the periods.

The back-scattering from compounds may be accurately predicted from the scattering of their constituent atoms.

Scintillation counters for the measurement of alpha, beta and gamma activity have gained prominence during the year. The subject is covered in Curran's book (25) and in a series of seven articles and four reports appearing in the March issue of Nucleonics (1954). Among the latter, Swank (103) considered recent advances, Linden (69) presented information on new photomultipliers and Harrison, Cowan and Reines (44) reported on large-volume liquid scintillators. Baskin (10), Belcher (11) (12), Davison, et al (26), Ittner and Ter-Pogossian (50), Kahn and Lyon (52), Spear (99) and Williams (115) also reported on the design and use of scintillation counters for the measurement of specific types of radiation or for spectrometry.

One of the most interesting developments is the use of solvents with liquid scintillators. For example, Terentiuk (104) improved a liquid scintillation counter for beta-ray measurements in which large amounts of solid material (up to 50 grams) were immersed in the liquid phosphor counting cell. With an anti-coincidence discriminator to eliminate high-energy cosmic radiation the measurable specific activity in a 30-minute counting period was found to be 10 $\mu\mu c/g$ for high-energy and 100 $\mu\mu c/g$ for low-energy beta particles. Improved end-window counting for low-level, low-energy beta emitters by anticoincidence counting was suggested by Crathorn (24) and the applicability of windowless and end-window

counters and survey meters for assaying gross activity in water was reviewed by an A.W.W.A. committee (3).

LeVine (67) described an inexpensive radiation detector useful for disaster purposes where residual gamma radiation is present. The instrument indicates less than 1 r/hr, from 1 to 10 r/hr, and above 10 r/hr by no lights, one light and two lights, respectively. The battery-powered unit could be left on continuously, since the current drain is negligible at low radiation levels.

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NOTE: "This Journal" refers to Sewage and Industrial Wastes Journal.

Addendum on Tritium, Carbon-14 and Miscellaneous Radioactivity Literature

Tritium

Kaufman and Libby (23) measured the abundance of cosmic-ray-produced tritium in a variety of natural waters in the Mississippi Valley, the Chicago area, and in a few places elsewhere in the northern hemisphere. Contents ranging between 0.5 and 67 tritium atoms per 10^{18} hydrogen atoms have been found. These correspond to an average cosmic-ray production rate of about 0.12 tritium atoms per cm^2 per second if the total rate of transfer of tritium into the oceans by oceanic rain and snow and by rivers carrying continental water is taken as being equal to the total production rate. A Th-activated KI phosphor was used by Jeffries and Owen (22) to detect tritium. The collector current of a photomultiplier tube is calibrated directly in T concentration. Grosse and Kirshenbaum (18) described techniques and experimental results in which molecular H of ground-level air was assayed for natural T content. Twenty-five cc. of H_2O were produced from atmospheric H taken 5 ft. off the ground in the Ne-He fraction of air at the Buffalo, New York (lat. =42.9°N) liquid air plant of the Linde Air Products Company. The whole sample corresponded to 60 to 70 million liters of air. Measurements of tritium in natural waters were made by Fireman and Schwarzer (16). The radioactivity of T is easily recognized and visually counted in a H_2-filled diffusion chamber. A 6-in.-diam. diffusion chamber, filled with 100 psi of H_2 obtained by completely

converting 14 cc. of water in a Mg furnace, is used to measure the T concentration in surface water of the Long Island Sound, in New Jersey well water, and in a number of rain and atmospheric moisture samples. These samples had T concentration (T/H ratios) that ranged from 10^{-15} to 3×10^{-18}. Some samples were measured directly, others required some electrolysis to give measureable T concentrations. No T could be detected in glacial water.

Libby (26, 27, 28) investigated methods of measurement of the activity of tritium at concentrations of one tritium atom for 10^{18} hydrogen. A volume of several liters of water in the residual 1 or 2 cc. is converted to H gas which is counted in a Geiger counter filled with a C_2H_4-A-H_2 mixture.

Beischer (3) recommended the utilization of tritium-labeled stearic acid monolayers as secondary standards in radioautography.

Carbon-14

Rosenthal and Anger (33) utilized the liquid-scintillation counter for very weak beta particles. The main features of the instrument are the use of an efficient liquid-scintillator solution (1.9 g. p-terphenyl and 0.020 g. diphenyltheratriene per liter of xylene) and a photomultiplier tube that has a very high signal-to-noise ratio. The method is sensitive to 430 $\mu\mu c$ H_3 and 18 $\mu\mu c$ C^{14}. De Vries and Barendsen (13) described a technique for the measurement of the natural activity of C^{14} in a CO_2-filled proportional counter.

The counting rate due to fresh C is 5.6/min., whereas the background is 3.9/min. The counter contains CO_2 at three atm., but the measurements indicate that it will be possible to increase the pressure at least up to about 15 atm. Up to now 30 samples have been dated.

Gora and Hickey (17) found that the self-absorption correction in end-window counting was a function of the geometry of the counting arrangement for weak beta emission.

Schwebel, Isbell and Moyer (34) presented a simple, rapid and precise method for the assay of C^{14}-labeled substances. The material to be assayed is dissolved in a suitable solvent, and the radiation from the solution is measured with a commercial gas-flow proportional counter. The characteristics of suitable solvents are discussed, and it is shown that formamide and ethylene glycol are particularly useful. The counting efficiency was found to be inversely proportional to the density of the solution counted.

Kulp (24) compared the radiocarbon counting techniques and showed that the proportional counting of CO_2 in large samples under pressure gave an accuracy comparable to the liquid-scintillation counting of 20 ml. CO_2 samples and greater accuracy than ionization or Geiger-counting.

Skok (36) discussed the counting techniques for the measurement of C^{14} activity and reviewed a number of experiments for the study of C^{14} toxicity in higher plants. A brief account of the biosynthesis of C^{14}-labeled dextran is included to illustrate

the general utility and methods of handling radiocarbon in biological research. Techniques of counting natural radiocarbon were reviewed by Arnold (2) and a method is described for counting samples for 48 hrs. in a scintillation counter. Faltings (15) used a proportional counter for C^{14} measurements.

Papers were presented by various authors (10) on the following subjects: C^{14} sample preparation and counting techniques; isotope methodology and miscellaneous agricultural applications; C^{14} studies in animals and health hazards; milk ingredient formation studies with C^{14} as tracer; C^{14} studies in photosynthesis and translocation; C^{14} studies on organic acid metabolism in plants. A method for counting C^{14} in volatile liquids was described by Maloney, et al (30) and applied to liquid-vapor equilibria studies. The application of C^{14} as a tracer in studies of multicomponent distillation was investigated and data are included from tracer studies of extraction equilibria.

Spectroscopy and Special Counters

Techniques in beta-ray spectroscopy were discussed by Cook (11). Both G-M and scintillation counters and electron photomultipliers were used as detectors. A Brookhaven National Laboratory report (5) considered an improved pulse-height analyzer and coincidence circuitry for the gray-wedge spectrometer; an improved rate meter with overlapping scales in the range 10 to 10,000 cps; and increased sensitivity of the Ca oxalate method of urinalysis for fission products.

Sinclair, Trott and Belcher (35) reviewed available methods for the absolute measurement of radioactive samples in liquid form. Sulit (36) reported on radiological monitoring during a water boiler-type reactor startup. Lacy and Kahn (25) evaluated the use of survey meters and electroscopes for monitoring radioactivity in water. Kenley (19) suggested a moisture-proof, heat-sealable cellophane containing a dimethoxy-diphenyl-diazo-bix-8-amino-1-naphthol-5-7-disulphonic acid dye as an economical material for use as a chemical detector of gamma radiation. An apparatus was described by Briere and Weill (4) which permits workers handling radioactive products to rapidly check all contamination traces on their hands, footwear, and clothing.

A scaler which makes use of subminiature techniques was described by Dietrich, et al (14). The scaler has a photomultiplier tube built in for alpha scintillation measurements as well as an external connector for G-M tube counting.

A new technique, which can be completed in 55 min., was proposed (32) for the detection of the position of small quantities of labeled chemical compounds on chromatographic paper.

A method was described (12) for the determination of traces of Rn in the atmosphere. The maximum sensitivity of the determination is approximately 1 μμc/l or one-tenth of the tolerance dose. The measuring apparatus used consists of an ionization chamber and a continuous current amplifier.

A carbon canister with face mask was proposed (20) for the collection of an exhaled radon sample for use in estimating body radium content in humans.

Bullen and O'Conner (6) considered the use of radium as a tracer in sewage flow measurements. They also found (7) that the radon content of raw sewage was 10-50 times greater than that of natural waters. Since soil gases are relatively rich in radon, it is conjectured that the radon is trapped in damp soil and infiltrated water carries it into sewage lines. Radon counts on sewage offer possibility for estimating dilution of outfalls, tidal effects on sewage disposal and infiltration into sewerage lines. Truesdale (39) proposed the use of rubidium as a tracer of sewage flow.

For the preparation of thin alpha sources, Milsted (31) proposed the sublimation of the oxides of tantalum filament at a temperature of about 2000°C in a high vacuum. This method was used for the preparation of isotope sources of all elements from thorium to curium. Lindsay (29) developed a method for spraying a conductive coating of uniformly thin layer of graphite on thin plastic films, such as might be used as windows in Geiger, proportional or other counting tubes. The coating is quick-drying and no more than 30 30 $\mu g/cm^2$ in thickness.

On radioautographic techniques, Aramu and Ladu (1) found a proportionality between uranium concentration and density of plates. Cheka (9) showed that each batch of NTA emulsion required separate calibration and Chanin and Barnes (8) determined the iodine number of developer solutions to assure consistency of development. Stewart and Bentley (37) reported on a new method for the analysis of uranium in sea water. The procedure utilizes a solvent mixture (dibutyl ortho phosphoric acid in CCl_4) to concentrated the uranium,

following which the amount present is estimated by fission-fragment counting in a neutron reactor. With no special precautions being taken, ocean water samples of 20 to 50 ml. size can be assayed with a precision of ± 5 percent. By using this method on a very limited number of samples, a value of 2.49 μg of U/l was found for Pacific Ocean water collected near the shore. A similar preliminary value of 5.1 μg U/l was found for a single sample taken from Great Salt Lake, Utah. Hutton (21) reviewed the radiation problem due to radium use, X-ray and the atomic energy program after 1942 and outlined the AEC authority and function as clarified by the Atomic Energy Act of 1954. Distribution, regulations, visitation program for end use agencies, and cooperation with states were discussed.

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